Key Takeaways

1. **Biodiversity**
   - Genetic biodiversity
   - Species biodiversity
   - Ecological biodiversity
2. **Patterns of biodiversity**
   - Latitudinal gradient
   - Species-Area Relationship
3. **Loss of biodiversity**

Key Takeaways

4. Result of biodiversity loss
5. Causes of biodiversity loss
6. Susceptibility to extinction
7. Red book and IUCN
8. Biodiversity conservation
9. Strategies to conserve biodiversity
10. Conventions on biodiversity

Summary

Biodiversity

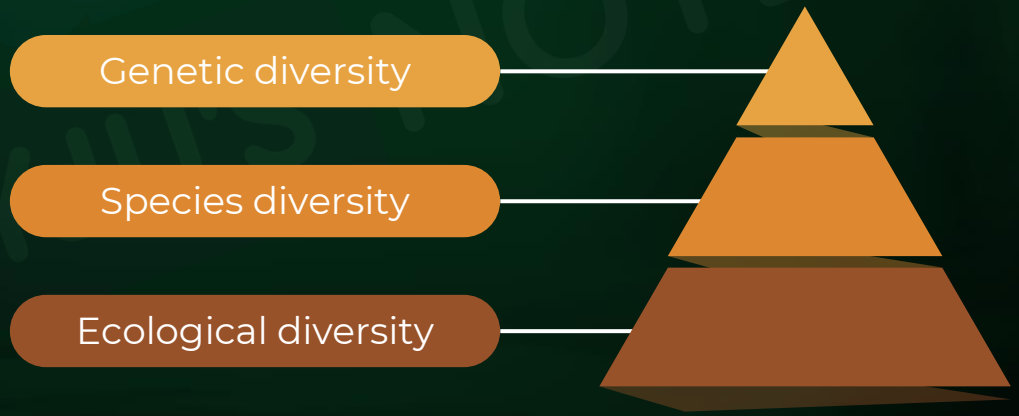
Biodiversity is the **total number of species** of plants, animals and microorganisms living on the earth.

- Biodiversity is **not uniform**, as it is **tremendous** in some places, **moderate** in others and **low** in certain regions.
- In the world, there are :
  - around 28,000 species of **fishes**
  - more than 20,000 species of **ants**
  - 3,00,000 species of **beetles**
  - nearly 20,000 species of **orchids**

Biodiversity

- **Edward O. Wilson** is the sociobiologist, who **popularized the term biodiversity**.
- He is regarded as the **father of biodiversity**.
- He described the combined biodiversity (or heterogeneity) **at all the levels of biological organisation** from macromolecules within the cells, genes, species, ecosystems and biomes.

Levels of biodiversity



Genetic Diversity

Genetic diversity is a **measure of variety in genetic information** contained in the organisms.

- It enables a population to **adapt to its environment** and **changes occurring around**.

Example :

- ***Rauwolfia vomitoria***, a medicinal plant.
- It produces a chemical called **reserpine**.
- The **potency and concentration of reserpine** produced **varies** for different members of this species growing in different Himalayan ranges.

Rauwolfia vomitoria

Genetic Diversity

Other examples found in India:

More than **50,000** genetically different **strains of rice**

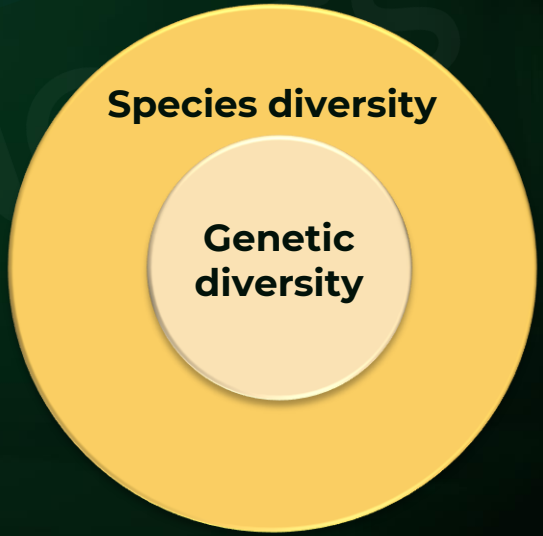
1,000 varieties of **mango** due to genetic variation

This genetic variation helps in formation of **ecotype** and plays important role in process of speciation.

Species Diversity

Species diversity refers to the **variety of species within a region.**
For example : Western Ghats have greater diversity of amphibians than Eastern Ghats

- It is a **product of species richness and species evenness**
- **Species richness** = Number of species / area
- **Species evenness** = Proportionate number of individuals of different species
- **Maximum taxonomic diversity** = Species of taxonomically different groups occur in almost equal abundance

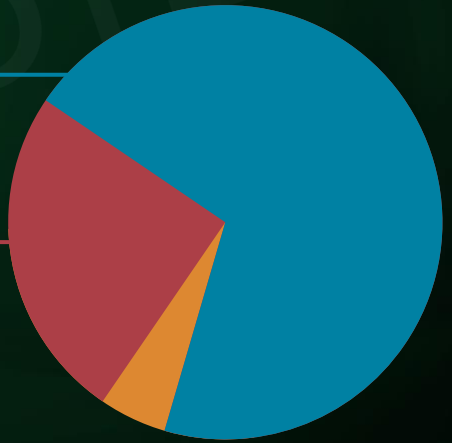


Species Diversity : Globally

- According to the **International Union Conservation of Nature and Natural Resources** (IUCN 2004)
  - Total number of plant and animal species = **more than 1.5 million**
- According to **Robert May**,
  - Number of global species diversity = about 7 million

More than 70% — Number of animal species

Nearly 22% — Plant (includes algae, fungi, bryophytes, gymnosperms and angiosperms



Earth's biodiversity based on the current available species data

Species Diversity : India

India has **45,000** species of plants.

India has nearly **90,000** species of **animals**.

India has **2.4 % of world's** land area.

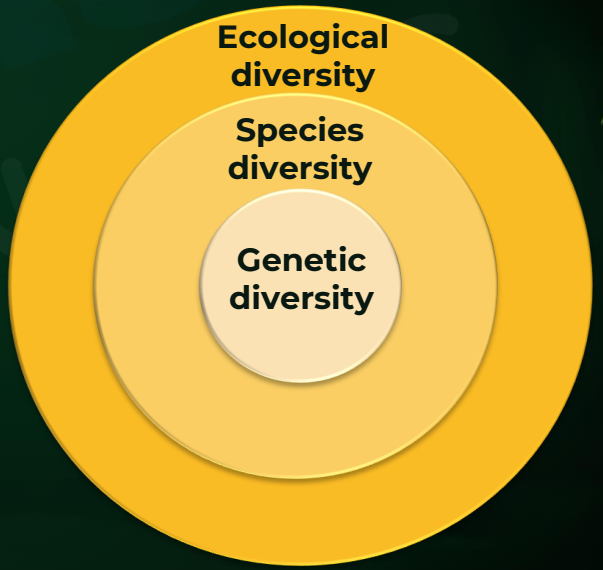
India contributes **8.1 % to global species diversity.**

- India is one of the **12 mega diversity** countries of the worlds.
- India is divided into 10 biogeographical regions.

Ecological Diversity

Ecological diversity refers to the **variety of ecosystem.**

Indicates diversity in :



Ecological Diversity

- For example:
  - Ecosystem diversity is **high in India** because of the occurrence of a **large number of ecosystems** like deserts, rainforests, mangroves, coral reefs, wetlands, estuaries and alpine meadows in comparison to small countries such as Norway.

Types of ecological diversity

Patterns of Biodiversity

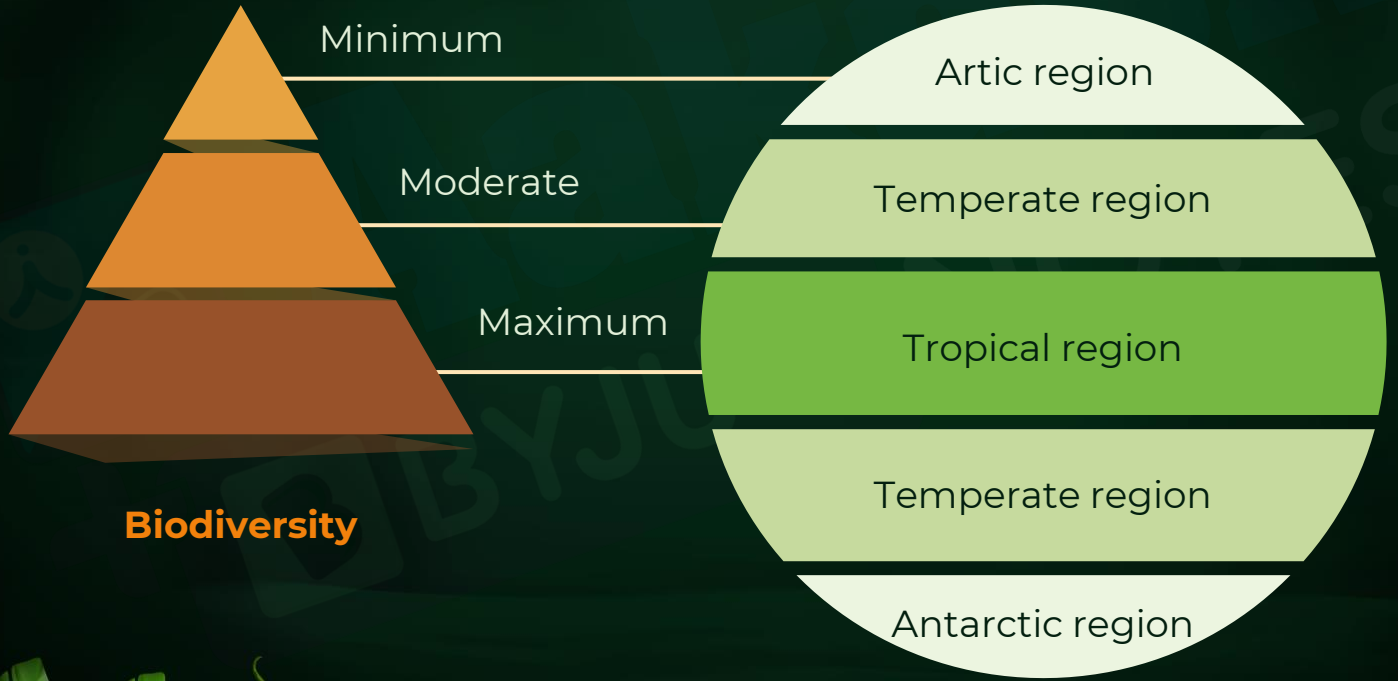
- The diversity of plants and animals is **not uniform** with **uneven distribution**
- There are many **interesting patterns** in diversity like
  - latitudinal gradient
  - altitudinal gradient
  - geographical gradient
  - topographical gradient
  - humidity gradient

The two most accepted and famous concepts of patterns of biodiversity are :

- Latitudinal gradient
- Species area relationship

Latitudinal Gradient

- The biodiversity **decreases** from the equator to the poles.



Latitudinal Gradient

Examples of **high diversity in tropical regions** (23.5 °N to 23.5° S):

- India has more than **1,200 species of birds** because the covered land falls in the tropical region.
- A forest in a tropical region like **Ecuador** has up to **10 times as many species of vascular plants** as a forest of equal area in a temperate region, like the Midwest of the USA.

Country	Region	No. of bird species
Columbia	Tropical region	1,400
New York	Temperate region	105
Greenland	Arctic region	56

Latitudinal Gradient

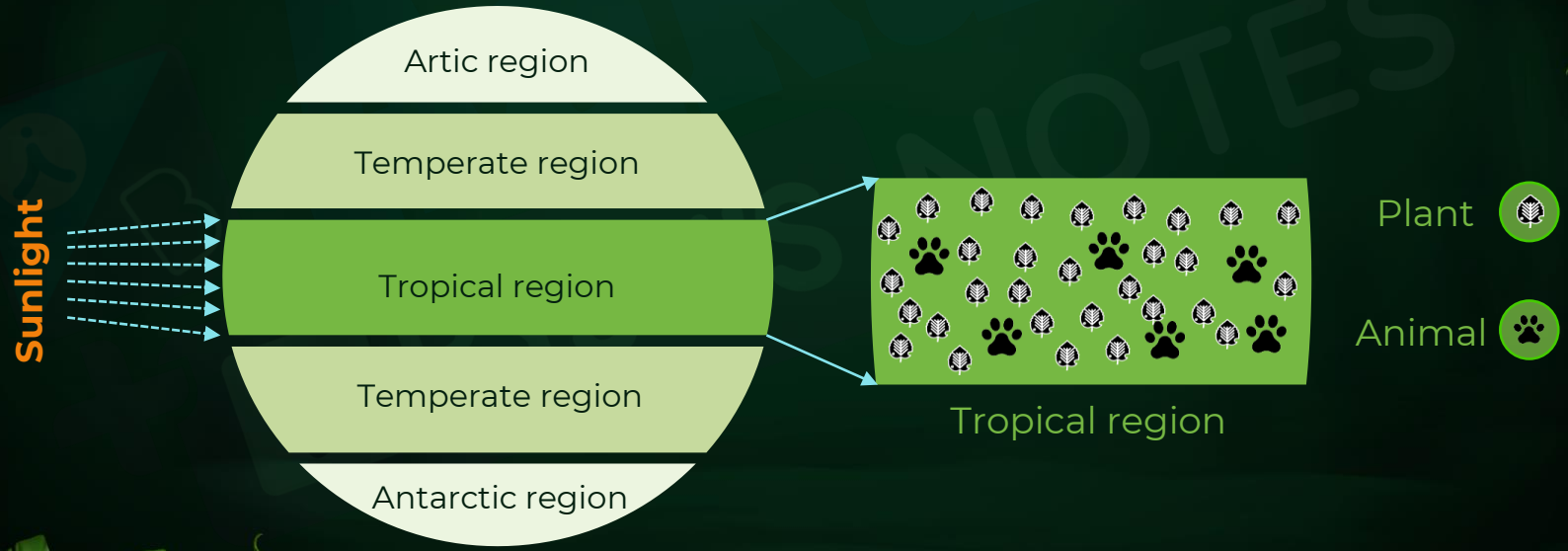
- The tropical **Amazonian rain forest** in South America has the **greatest biodiversity on Earth.**
- In these rain forests, there might be at least **two million insect species** yet to be discovered and named.

Taxa	No. of species
Plants	More than 40,000
Mammals	427
Birds	1,300
Reptiles	378
Amphibians	427
Fishes	3,000
Invertebrates	More than 1,25,000

Latitudinal Gradient

Cause of **high diversity in tropical regions :**

1. Tropical areas receive **more solar energy.** Thus, its communities are more productive which supports wider range of species.



Latitudinal Gradient

2. **Favourable conditions** in tropical regions are due to
   - warm temperatures
   - humidity

- Therefore, these regions are
  - less seasonal
  - relatively more constant
  - predictable

- This helps tropical organisms to **gain more niche speciation** and **leads to greater species diversity.**

3. **Speciation** is a function of time.

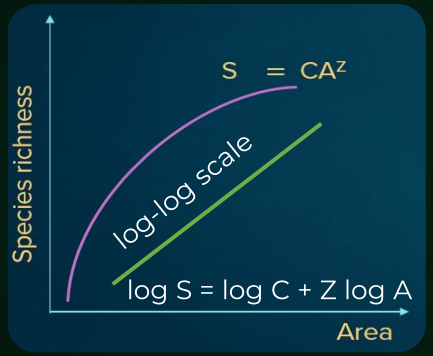
- Due to frequent glaciations in temperate areas, many species were killed.

- However, in tropical region, diversification occurred due to stable conditions.

- Due to stability, tropical species continued to **flourish** and **evolved undisturbed for millions of years.**

Species - Area Relationship

- Alexander von Humboldt explored South American jungles and found that within a region, **species richness increases with increase in area but only up to a limit**
- Relationship between species richness and area = Rectangular hyperbola



S = species richness
A = area
Z = slope of the line (regression coefficient)
C = Y-intercept

Significance of slope regression / regression coefficient (Z):

The relationship indicates that,
S ∝ A

- For small area, Z = 0.1 to 0.2
- For larger area, slope of line is much steeper than smaller area, Z = 0.6 to 1.2

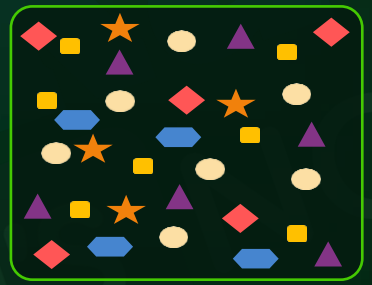
Importance of Species Diversity

- Variety of species in a community **plays an important role** in the functioning of the ecosystem
- Rich biodiversity is important for **stability, productivity, resilience, alternative pathways and health of ecosystem**

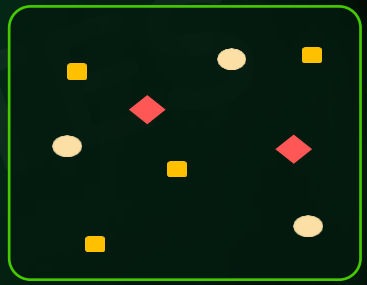
1. **Stability :**
   - Stable community should not show too much variation in productivity from year to year.
   - It must be either resistant or **resilient to occasional disturbances** (natural or man-made).
   - It must also be **resistant to invasions by alien species**.
   - Communities with **more species** = **more stable**.

Importance of Species Diversity

- **David Tilman's** worked on long-term ecosystem experiments.
- He studied **connectivity between community stability** and **species richness** by using outdoor plots.
- He confirmed that
  - plots with more species showed less year-to-year variation in total biomass.
  - increased diversity contributed to higher productivity.



(A)
More species diversity
More stable community



(B)
Less species diversity
Less stable community

Importance of Species Diversity

2. **Ecosystem health :**
   - Rich biodiversity is not only essential for ecosystem health, but also for survival of human race on earth.
   - Because **larger number of species, have high number of niches, more interactions and more inter-relationships.**

- **Paul Ehrlich**, Stanford ecologist, gave a proper perspective through an analogy - the **'rivet popper hypothesis'**
- In his analogy,
  - airplane = ecosystem
  - rivets = species

Rivet Popper Hypothesis

- In an airplane (ecosystem), all parts are joined together using thousands of rivets (species).
- If a **rivet pops out** (causing species to extinct), this may **not affect flight safety** (proper functioning of the ecosystem) initially.
- However, as more and **more rivets are removed**, the **plane becomes dangerously weak** over a period of time.
- **Loss of rivets** on the wings (key species that drive major ecosystem functions) is **more serious threat** to flight safety than loss of a few rivets.

Species which plays a very critical and pivotal role in the functioning and stability of the entire ecosystem are called **keystone species**. E.g., Tiger, shark, vulture etc.

Loss of Biodiversity

- The biological wealth of our planet has been declining rapidly.
- Complete disappearance or **extinction** of a species results in **complete loss of genetic information** contained in it.

Natural extinction

Due to **change in environmental conditions**, species disappeared in the geological past at a **very slow rate**, which is known as natural extinction.

Mass extinction

It is dying off or extermination of a **large number of species** due to **catastrophes**. Five episodes of mass extinction of species has occurred.

Loss of Biodiversity

Anthropogenic extinction

It is extermination of species caused **directly or indirectly by human activities** like habitat destruction, over-exploitation, hunting, pollution etc.

- Colonisation of tropical Pacific Islands by humans have resulted in extinction of more than 2,000 species of native birds.

Loss of Biodiversity

IUCN Red list documents the extinction of species

IUCN Red List (2004)

- **338** vertebrates
- **87** plants
- **359** invertebrates

784 species have become extinct, in last 500 years

- Some examples include:

Dodo (Mauritius)

Steller's Sea Cow(Russia)

Quagga (Africa)

Thylacine (Australia)

Caspian tiger

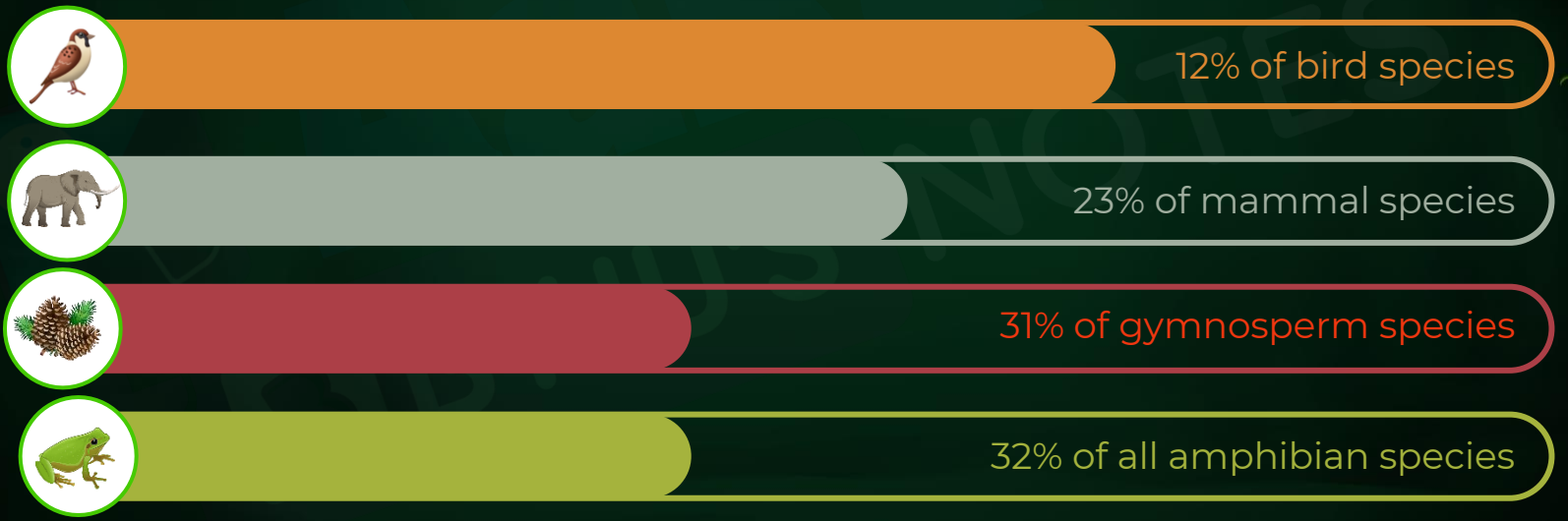
Javan tiger

Bali tiger

27 species have become extinct, in last 20 years

Loss of Biodiversity

- Extinctions across taxa are **not random.**
- Some groups like amphibians appear to be more vulnerable to extinction.
- Global threat of extinction = 15,500 species



Global species : Threat to extinction

Loss of Biodiversity

- **Anthropogenic extinction** will cause the **6th mass extinction of species**.
- The current species extinction rates are estimated to be **100 to 1,000 times faster** than the natural extinctions.
- Ecologists warn that if the present trends continue, nearly half of all the species on earth might be wiped out within the next 100 years.

Natural mass extinctions

Anthropogenic activities are leading to 6th mass extinctions

Result of Biodiversity Loss

- Loss of biodiversity in a region may lead to :

Decline in plant **production** and **productivity**

Reduced resistance to environmental perturbations like drought

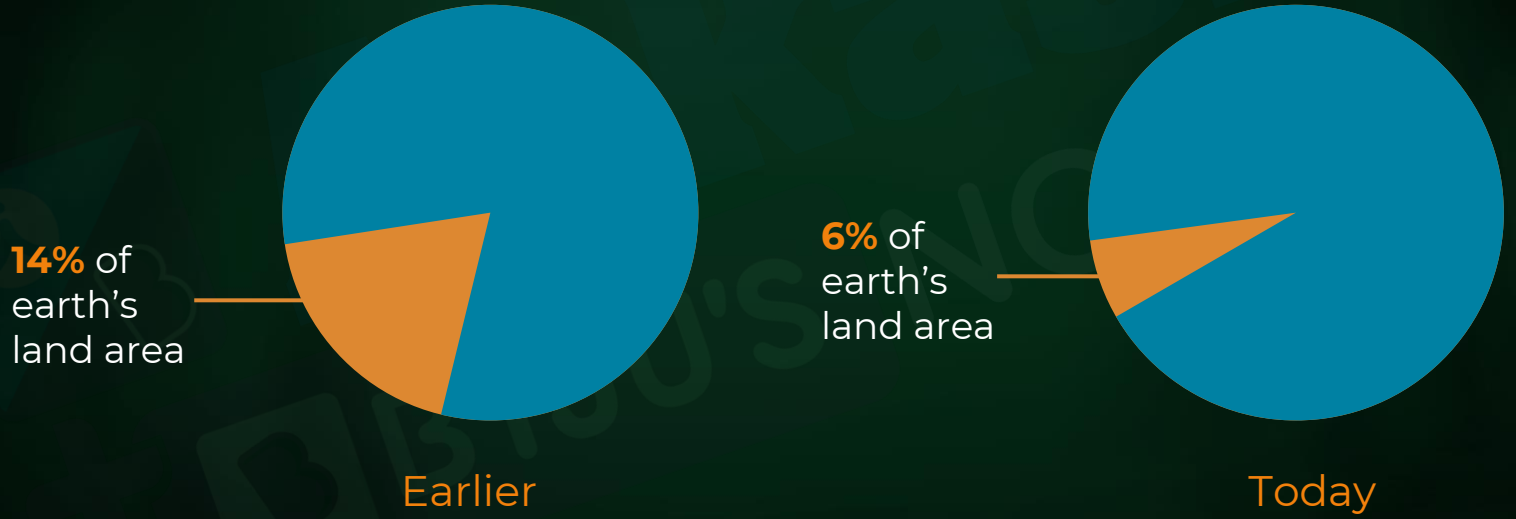
Increased variability of ecosystem processes like productivity, water use, pest and disease cycle

Causes of Biodiversity Loss

Four major causes of biodiversity losses :

Habitat Loss

- Deforestation, filling of wetland, ploughing of grassland or burning of the forest **destroyed** or **changed the natural habitat**



Habitat loss of tropical rainforests

Habitat Loss

- The **Amazon rainforest** is huge and is called the **‘lungs of the planet’** and harbours probably millions of species.
- It is being cut and cleared for cultivating soybeans or for conversion to grasslands for raising beef or cattle.

Habitat Loss

- Pollution may reduce or eliminate populations of sensitive species.
  - **Use of pesticides** are linked with decline in fish-eating birds and falcons
  - **Lead poisoning** causes mortality of duck, swans and cranes
  - **Eutrophication** (nutrient enrichment) of water bodies drastically reduces species diversity

Water pollution

Landfills

Industrial pollution

Habitat Loss

- **Fragmentation:** Large habitat broken into smaller fragments **due to human activities**, such as human settlements, building of roads, digging of canals etc.

Large habitat

Large habitat broken, due to fragmentation

- Animals which require larger territories, for example., mammals, birds and migrating animals are **badly affected which leads to decline in their population**.

Over Exploitation

- Humans are **dependent on nature** for food, shelter, medicines and clothing.
- Whenever, **'need' turns to 'greed'**, it leads to **over-exploitation of natural resources.**

Over exploitation of a **particular species** reduces size of its population to an extent so that it **becomes vulnerable to extinction.**

Over Exploitation

Example of extinct species

Passenger pigeon

Dodo

Steller's Sea Cow(Russia)

- Many species have gone extinct in the last 500 years **due to overexploitation** by humans.

- **Overharvesting** of commercially important marine fishes, **endangered its population.**

Alien Species Invasions

- **Alien species:** are the new species entering a geographical region; also known as **exotic** or **non-native** species.
- When alien species are introduced unintentionally or deliberately for any purpose, **some** of them **turn invasive**, and **cause decline** or extinction of indigenous or **native species**.
- For example,

Carrot grass (*Parthenium*)

Water hyacinth

African catfish (*Clarias gariepinus*)

Co-extinctions

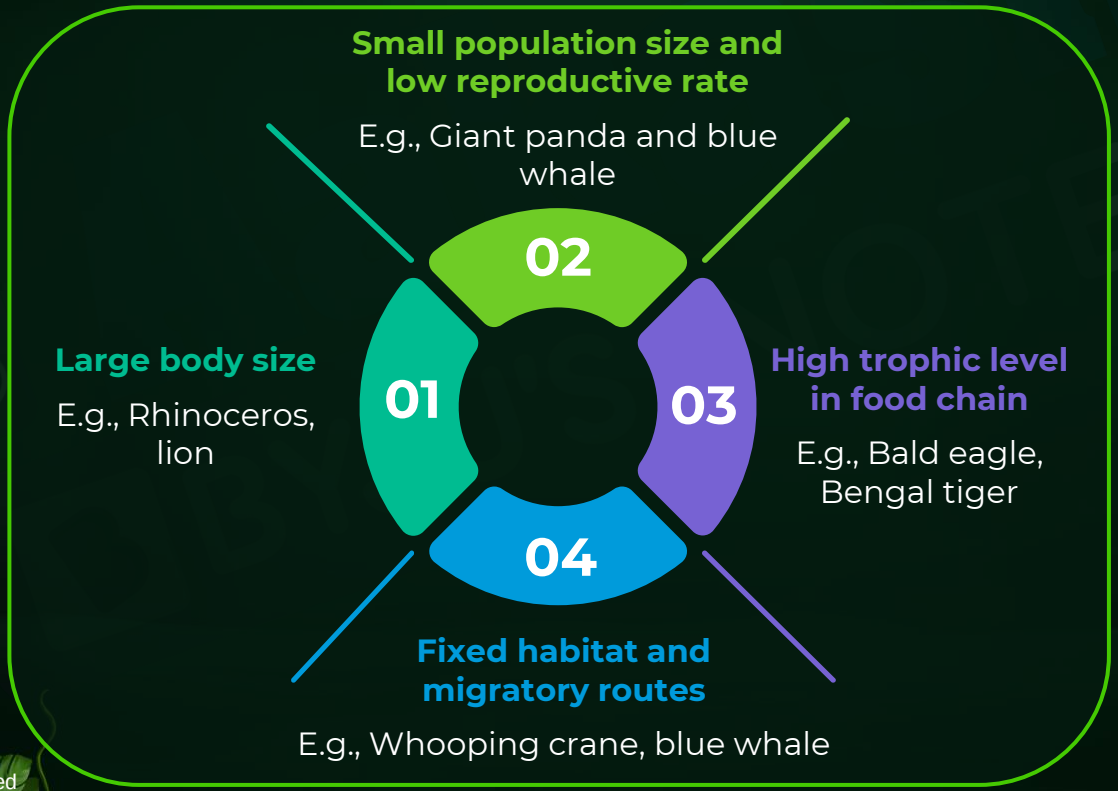
- When a species becomes extinct, the plant and animal **species associated** with it also become extinct.
- For example, **co-evolved plant-pollinator mutualism**, where extinction of one leads to the extinction of the other.
- When a host fish species becomes extinct, its association with parasites also meets the same fate.

Plant - pollinator

Host - parasite

Susceptibility to Extinction

- Species more susceptible to extinction have following characteristics:



Red Book and IUCN

- **IUCN** is **International Union for Conservation of Nature and Natural Resources,** formerly called as **World Conservation Union** (WCU) from 1990 to 2008.
- It has headquarters at Gland, **Switzerland.**
- It maintains **Red Data Book** or **Red List,** which is a catalogue of **threatened plants** and **animals** facing risk of extinction.

Threatened species

Threatened species is the one which is **liable to become extinct** if they are not provided with proper habitat, food and protection to obtain its full biotic potential.

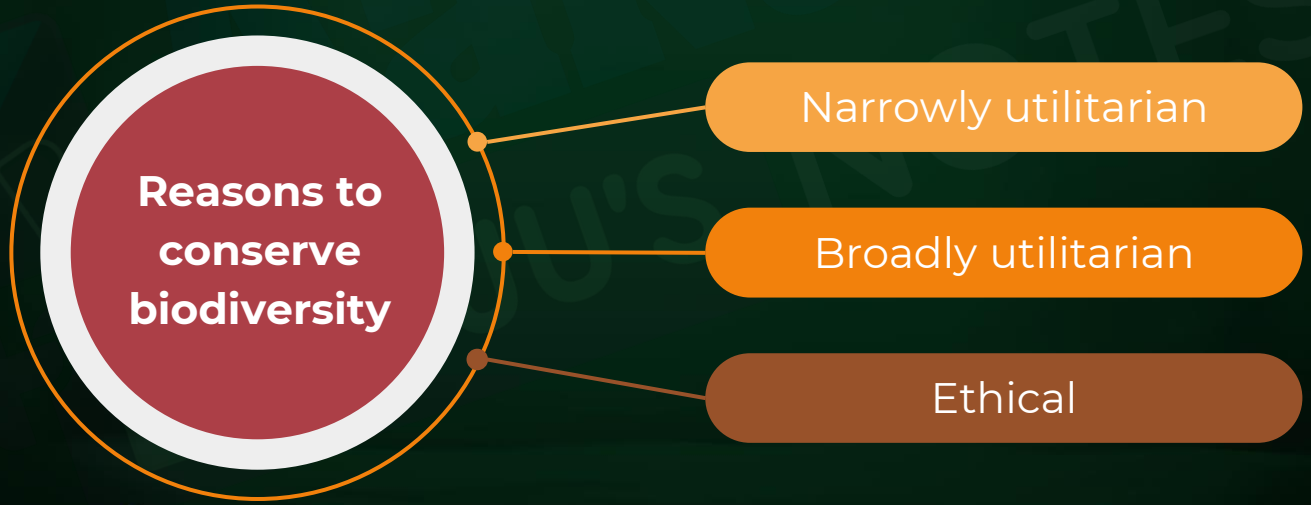
Red Book and IUCN

- Red list has **8 categories** of species :

Taxa	No. of species
Extinct [EX]	Last individual has died
Extinct in the wild [EW]	Failed to record an individual in known habitat
Critically endangered [CR]	Extremely high risk of extinction in the wild in the immediate future
Endangered [E]	Very high risk of extinction in the wild in the near future
Vulnerable [V]	High risk of extinction in the wild in the medium-term future
Lower risk [LR]	Evaluated but they are not [CR], [E] or [V]
Data deficient [DD]	Inadequate data for assessment
Not evaluated [NE]	Not yet assessed

Biodiversity Conservation

- Ecosystems are undergoing **change due to several factors** like pollution, invasive species, over-exploitation by humans, climate changes etc
- It is important to recognise that **diversity at all levels** - genetic, species and ecological and **needs to be conserved**.



Narrowly Utilitarian

- Human derive countless direct economic benefits from nature

Food

Vegetables, fruits, eggs, meat, cereals, pulses etc.

Fiber

Jute, flax, hemp, cotton, coir etc

Firewood

For cooking and heating

Constructional material

Timber in construction work, furniture, sport goods, musical instruments etc.

Narrowly Utilitarian

Drugs

Reserpine, derived from *Rauwolfia serpentina which is used against high B.P*

25% of drugs sold in market are derived from plants. For example, morphine, quinine, liquorice etc.

Industrial products

Tannins are used in leather industry, lubricants, dyes, resins, perfumes, paper, rubber etc.

Bioprospecting is a vigorous exploring of molecular, genetic and species level diversity for products of economic importance.

Broadly Utilitarian

Ecosystem services that nature provides

Oxygen

Plants replenish 0_2 in the atmosphere through photosynthesis

Pollination

A number of organisms, like bees, birds, bats, are involved in pollination which is essential for formation of fruits and seeds

Flood and erosion control

Plants retain water and prevent run off. Plant roots hold the soil and prevent soil erosion.

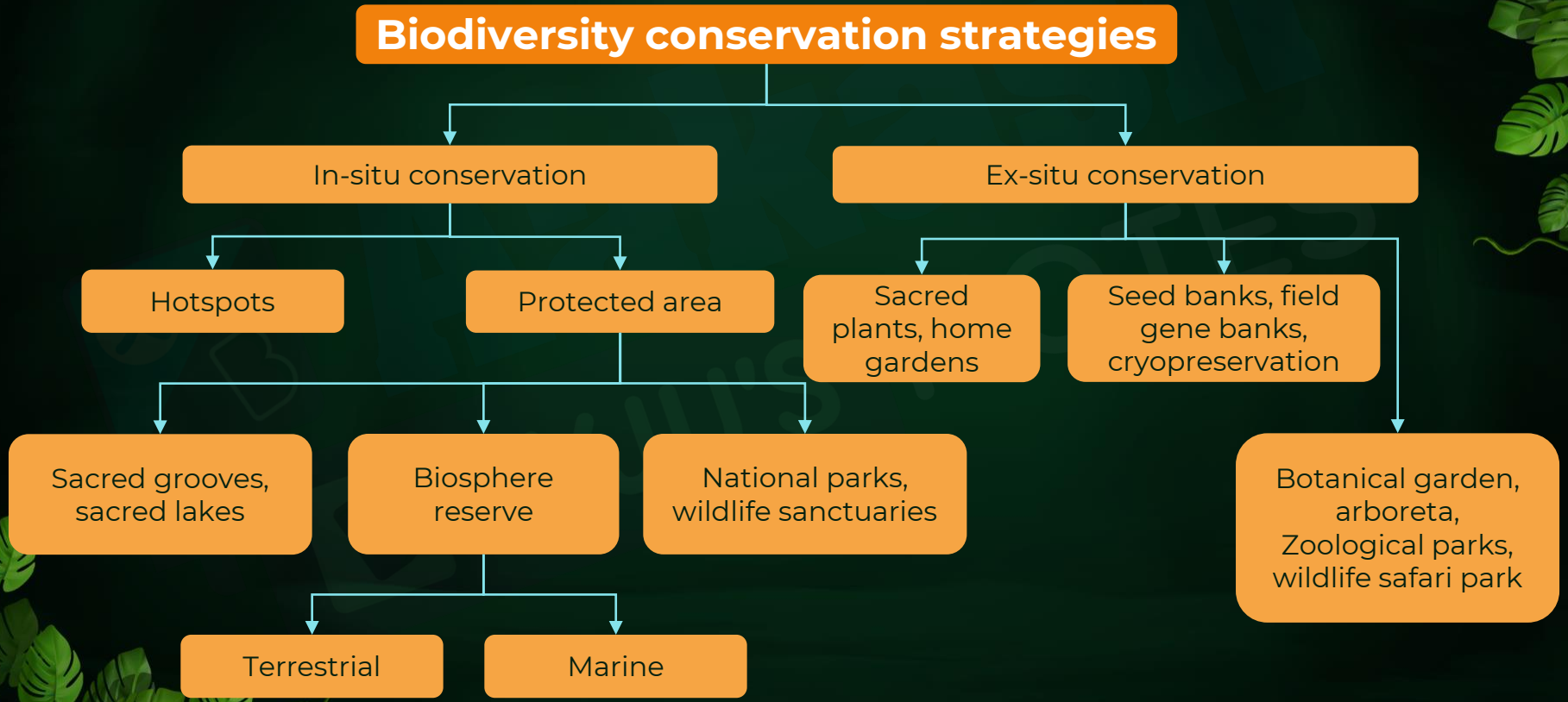
Aesthetic pleasure

Biodiversity has an attraction value

Biodiversity Conservation

- There are millions of plants, animals and microbial species on this planet, regardless of their usefulness or economical value, **every species has an intrinsic value**.
- Humans have a **moral** and **ethical duty** to take care for their well-being and **pass on our biological legacy in good order to future generations** rather than destroying them.

Strategies to Conserve Biodiversity



In-situ conservation

- Ecosystem and its biodiversity at all levels are **protected on site**, which means we save the entire forest to save the tiger.
- Strategies are of two types : hotspots and protected areas

A. Hotspots

- Designated priority areas, with hotspot of richest and the most threatened reservoirs of plant and animal life on earth
- Key criteria for the designation of hotspots are :

Very high levels of species richness

High degree of endemism

Degree of threat

In-situ conservation

Initially 25 + 9 added later = 34 hotspots in the world

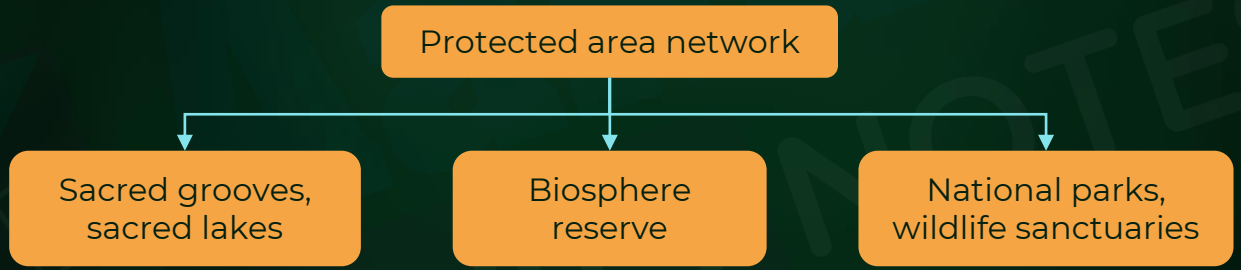
Covers 2% of land – dense in biodiversity
Protection of these hotspots can decrease mass extinction by 30%

Hotspots in India
Western Ghats and Sri Lanka
Indo - Burma
Himalaya

In-situ conservation

B. Protected areas

- Especially dedicated areas for the **protection and maintenance of biological diversity**



- In India :
  - Biosphere reserves - 18
  - National parks - 106
  - Wildlife sanctuaries - 565

In-situ conservation

National parks :

- Maintained by government and reserved for betterment of wildlife
- The earliest national park is **Yellowstone** in **USA** and **The Royal** in **Sydney, Australia.**
- The first national park in India was **Jim Corbett National Park.**

NOT ALLOWED

- Habitat manipulation
- Grazing
- Timber collection

Important protected animals and their National parks

Taxa	Protection started in	National parks/ Sanctuaries
Lion (*Panthera leo persica*)	**1972**	Gir National Park (Gujarat)
Tiger (*Panthera tigris*)	**1973**	Corbett National Park (Uttarakhand) Sunderbans Tiger Reserve (Bengal)
Snow leopard (*Panthera uncia*)	**2009**	Khangchendzonga National Park (Sikkim)
Rhino (*Rhinoceros unicornis*)	**1987**	Kaziranga National Park (Assam)
Elephants (*Elephas maximus*)	**1991**	Simlipal Sanctuary (Orissa)

In-situ conservation

Sanctuaries:

- Land where animals are **protected from all types of exploitation** and **habitat disturbances.**

ALLOWED

- Private ownership
- Timber collection
- Collection of forest products
- Tilling of land

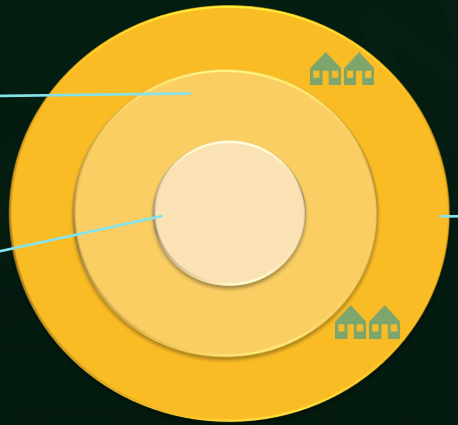
In-situ conservation

Biosphere reserve :

- Special category of protected areas, wherein **tribal people are an integral component of the system**
- Launched by UNESCO's Man and Biosphere Programme (**MAB**) in 1975
- **Biosphere reserves in India** - 18

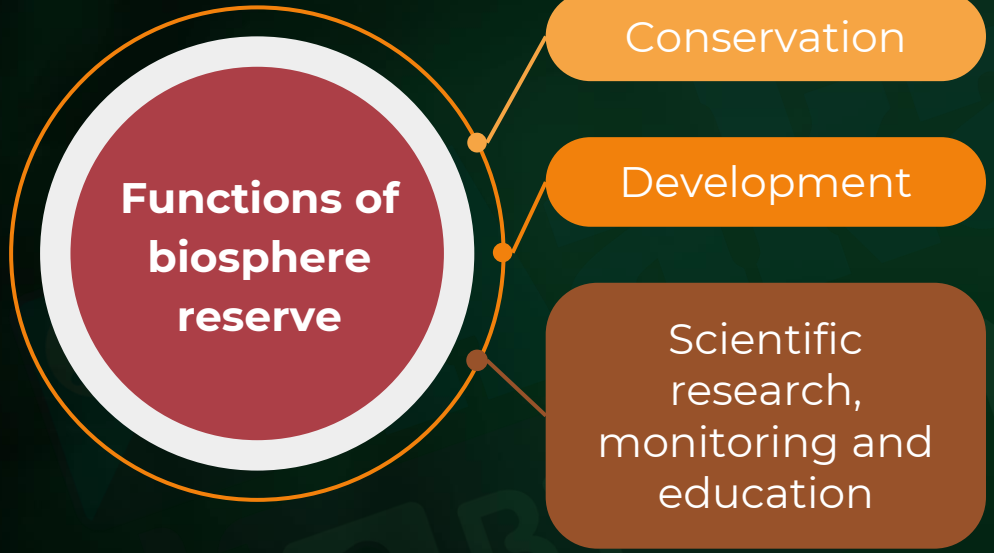
Buffer zone: are for research and educational purposes

Core zone: is an undisturbed and legally protected ecosystem



Transition zone: Activities like settlements, cropping, forestry, recreation, take place with proper harmony and conservation goals

In-situ conservation



Some biosphere reserves in India
Nanda Devi, Uttarakhand
Manas, Assam
Nokrek, Meghalaya
Sunderbans, West Bengal

In-situ conservation

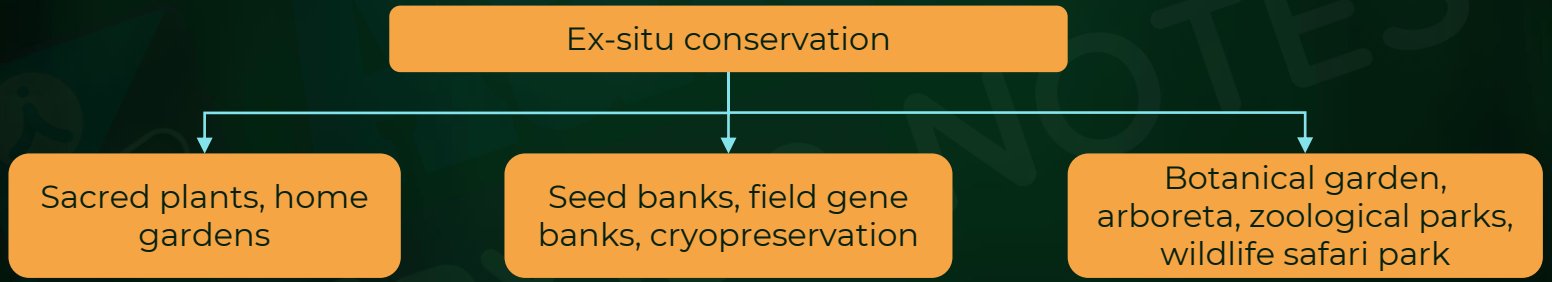
Sacred grooves :

- In many cultures tracts of forest were **set aside**, and all the trees and wildlife within were **totally protected**
- Also known as **Islands of Pristine Forests**
- **Sacred lakes:** Pushkar lake in Rajasthan; Khecheopalri lake in Sikkim
- **Sacred plants:** *Ocimum sanctum* (Tulsi), *Ficus religiosa*, *Elaeocarpus floribundus* (Rudraksha) etc.

Sacred groves in India
Khasi and Jaintia Hills in Meghalaya
Aravali Hills of Rajasthan
Western Ghat regions of Karnataka and Maharashtra
Surguja , Chanda and Bastar areas of Madhya Pradesh

In-situ conservation

- Threatened animals and plants are taken **away from their natural habitat** and are placed **under special care and protection.**
- Ex-situ conservation is the most desirable approach for urgent measures for endangered and threatened species.



Ex-situ conservation

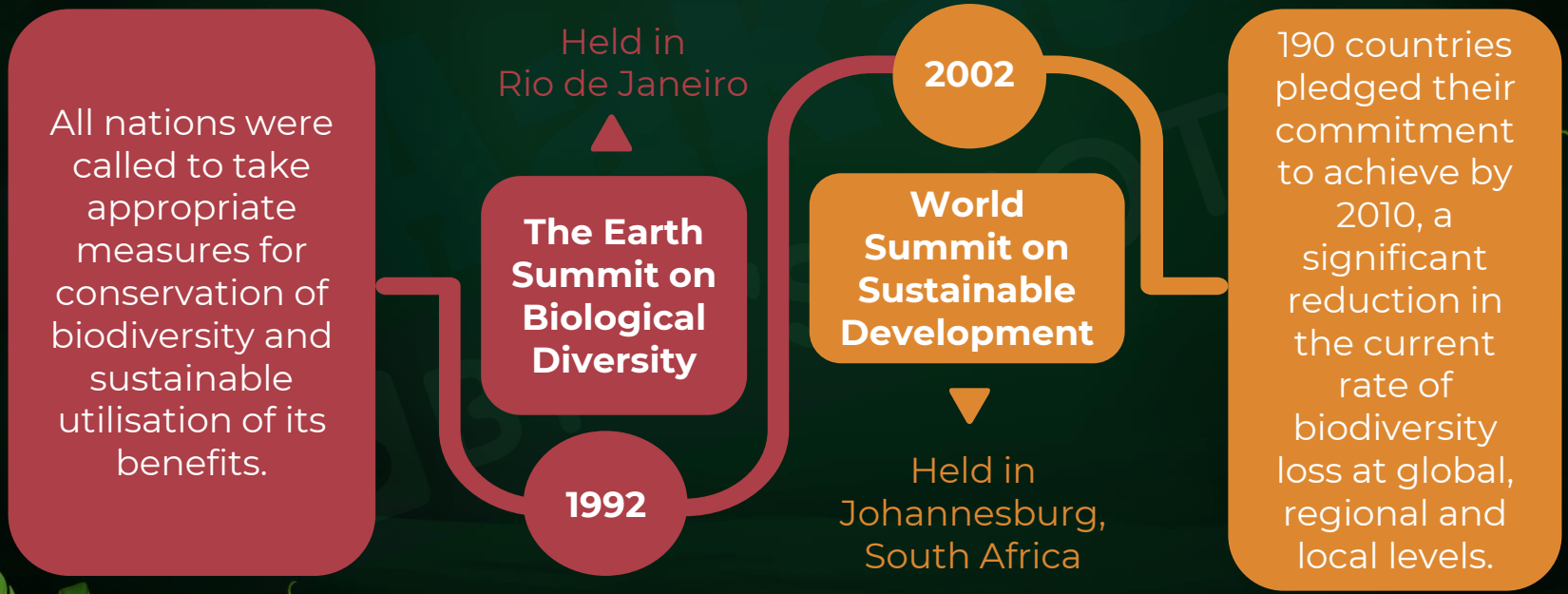
Cryopreservation for preserving threatened species gametes in viable and fertile conditions or longer period of time.

Tissue culture for propagation of plants

Seed banks for keeping seeds of different genetic strain of commercially important plants.

Conventions on Biodiversity

- Biodiversity knows no political boundaries and its conservation is therefore, a collective responsibility of all nations.

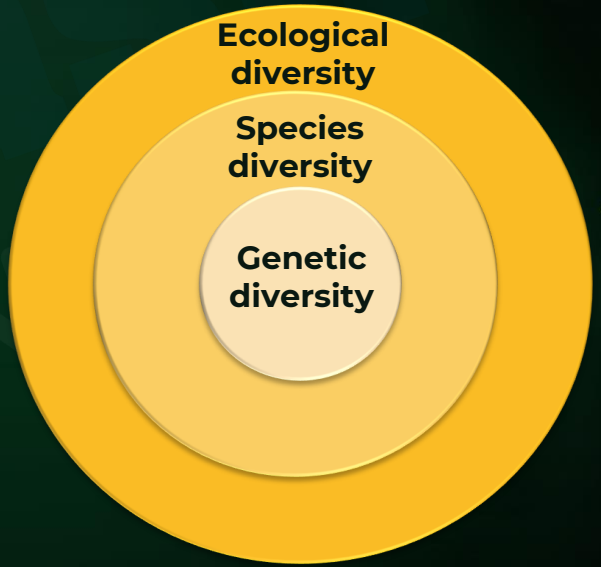


Summary

Genetic diversity is a **measure of variety in genetic information** contained in the organisms.

Species diversity refers to the **variety of species within a region.**
For example: Western Ghats have greater diversity of amphibians than Eastern Ghats

Ecological diversity refers to the **variety of ecosystem.**



Summary

Natural extinction

Due to **change in environmental conditions**, species disappeared in the geological past at a **very slow rate**, which is known as natural extinction.

Mass extinction

It is dying off or extermination of a **large number of species** due to **catastrophes**. Five episodes of mass extinction of species have occurred.

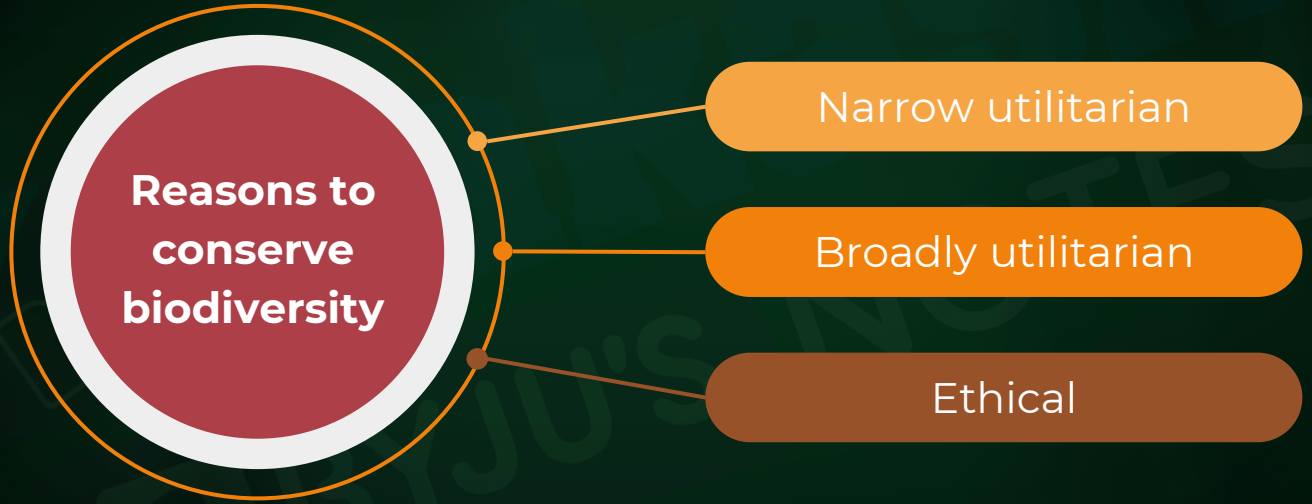
Anthropogenic extinction

It is extermination of species caused **directly or indirectly by human activities** like habitat destruction, over-exploitation, hunting, pollution etc.

Summary

Four major causes of biodiversity losses :

Summary



Summary